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PREVENTING Mold-Caused Toxins IN Farm Commodities

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ABOUT THIS REPORT . . .

Mycotoxins (mold-caused toxins) have been the focus of intensified interest on the part of medical and agricultural researchers, food and drug regulatory officials, and of producers, handlers, and distributors of farm commodities in the past several years.

The loss of a large number of turkey poults in England in 1960 was traced to particular mycotoxins—since identified and named aflatoxins—in moldy peanut meal. Thus alerted to the problem, the U.S. Department of Agriculture, the Department of Health, Education, and Welfare, and the peanut and grain industries are carrying out a plan to safeguard our country from the danger of aflatoxin getting into food or feed channels.

The precise combinations of moisture, temperature, and other variables that cause certain strains of common molds to produce mycotoxins have not been determined. Prevention of molds has therefore assumed increased importance as a practical safeguard against possible contamination of agricultural commodities.

Mold prevention to maintain quality of farm products has long been emphasized. Research on mycotoxins by USDA, the Food and Drug Administration, various State agricultural experiment stations, and industry is being greatly expanded.

Despite the unknowns, we have enough knowledge to reduce molds sharply and minimize any possibility of mycotoxins in agricultural products.

This report includes reminders of recommended farming practices for producing peanuts, cottonseed, soybeans, ear corn, shelled corn, rice, and other small grains that are high in quality and less likely to become contaminated by molds and mycotoxins.

Information in this report was provided by the Agricultural Research Service, the Agricultural Marketing Service, the Agricultural Stabilization and Conservation Service, and the Cooperative State Research Service of USDA, and several State agricultural experiment stations.

PREVENTING MOLD-CAUSED TOXINS IN FARM COMMODITIES

From time out of memory, mold has been a recurring problem facing farmers, handlers, and users of agricultural products.

While some molds perform beneficial functions, other molds produce toxins that are harmful to livestock and poultry.

Since 1960 interest of medical and agricultural researchers in mycotoxins, as mold-caused toxins are called, has been greatly stimulated by reports from Britain of a large number of turkeys poisoned from feeding on contaminated peanut meal. Analysis of the peanut meal showed that it contained a toxic byproduct of a common mold, *Aspergillus flavus*. The mycotoxin was given the name aflatoxin.

EXTENT AND NATURE OF THE PROBLEM

We have little information on the extent and severity of the mycotoxin problem. However, some strains of other common molds besides *A. flavus* are known to be capable of producing toxins—certain strains of *A. glaucus, A. fumigatus, Penicillium rubrum,* and *P. puberulum,* among others. And numerous crops beside peanuts are susceptible to contamination by toxin-producing mold strains under certain not yet fully defined conditions. Cottonseed, soybeans, corn, rice, a number of other small grains, and forage crops are among the farm commodities in which mycotoxins have been found to occur naturally in a few isolated instances or have been produced experimentally.

Mycotoxins are also produced by some other parasitic fungi. For example, the grain diseases, ergot and scab, are caused by fungus parasites that develop in growing cereals and produce toxins—ergot by certain *Claviceps* species and scab by some *Giberella* and *Fusarium* species. However, this report is primarily concerned with mold-caused toxins on harvested crops and how to prevent them.

While molds are thought of as conspicuous growths, some fungi are minute and can be detected only by laboratory methods.

Sporadic Reports of Animals Harmed by Moldy Feed

Although rare in proportion to the livestock and poultry populations, cases of animal injury from consuming moldy feed are reported from time to time in this country. For example, an instance of cattle made ill by moldy peanut meal was reported in 1883, but since aflatoxin had not been isolated at that time it is not known whether this particular mycotoxin was involved. Instances of swine, cattle, and poultry injury by moldy field corn have also been reported occasionally. Some cases of animal illness from moldy rice, malt, and hay and other forage crops are also on record.

Scientists generally are inclined to conclude from these occasional reports that mold poisoning among livestock and poultry in this country is relatively infrequent and sporadic. However, they emphasize that extensive research has not been done in the field.

Aflatoxin is not a problem in vegetable oils extracted from oilseeds because it is removed by the alkali refining and bleaching process.

Animals Vary in Tolerance to Mold Byproducts

Mold byproducts toxic to lower forms of animal life are not necessarily harmful to humans. Penicillin, for example, which is produced by a mold, helps man fight disease by killing or inhibiting certain bacteria.

No studies are available to indicate whether aflatoxin is harmful to man. But experiments have shown a wide variation of tolerance among various species of warmblooded animals studied. Ducklings are extremely susceptible and are widely used as test animals to confirm the presence of aflatoxin. Sheep, on the other hand, are relatively resistant. A British scientist has ranked a number of common domestic animals in diminishing order of susceptibility as follows: ducklings, turkeys, pheasants, pigs, cattle, and sheep. The young of most species are more susceptible to aflatoxin than older animals.

Why Molding Should Be Prevented

Precise information is lacking about the particular combinations of variables that cause certain strains of a number of common molds to produce toxic byproducts. Consequently, mold prevention is receiving increased emphasis as a practical means of avoiding possible danger from mycotoxins.

There are many other good reasons for mold prevention. Mold causes bad odor, makes feed less palatable and nutritious for livestock, and renders some foods undesirable for human consumption. Mold causes seeds to lose viability, making them unsuitable for planting. Furthermore, mold lowers the grade and price of farm products and may even prevent sale.

CROP QUALITY IS INDUSTRY-WIDE CONCERN

The quality of foods and feeds is a continuing concern of growers, processors, dis- Department of Agriculture, the Department of Health, Education, and Welfare, tributors, and users of various crops. Now that toxins have been identified with moldy agricultural commodities, mold prevention is of direct concern to industry and Government for assuring quality and protecting consumers.

This concern is evidenced by the quick response of the peanut industry, the U.S. State agricultural experiment stations, and various other State and private groups to the aflatoxin problem. Industry and Government have a cooperative program to guard against the use of peanuts containing aflatoxin for food or feed.

Under the program, USDA price support for the 1964 peanut crop was changed to provide that only high-quality peanuts would be used for food products, and damaged peanuts would be diverted to other suitable uses. This provision was based on findings that aflatoxins are generally associated with low-grade, off-color, damaged peanuts—and is in line with the longtime goal of the peanut industry to maintain and increase the market for edible peanuts through quality control and improvement. The new marketing program also provided that peanut meal being sold or processed for animal feeding would be checked for aflatoxin and thus could be diverted to suitable uses if found to be contaminated.

Other phases of the cooperative program of government and industry to prevent peanuts with mycotoxins being used for food or feed include: Educational assistance to the peanut industry to encourage full use of improved methods of growing, harvesting, storing, and processing peanuts, with USDA and the State Agricultural Extension Services cooperating; a stepped-up research program for better ways of preventing mold damage and improving the quality of peanuts; and Federal-State inspection of all lots of peanuts before shipment for use as food. In addition, USDA's Agricultural Marketing Service has made available to the industry laboratory services in testing peanuts and peanut products for aflatoxin.

Producers and distributors of other agricultural commodities are showing a like interest in maintaining the quality of their products and in detecting and eliminating any possible danger from aflatoxin or other mycotoxins. Current efforts to prevent molds from developing in the various crops reflect this concern.

Farmers Have Major Responsibility

We do not know enough about how specific cultural practices during crop growth affect the later development of mold in a crop. We do know, however, that the harvesting and handling phases are critical. Failure to take the proper measures then can mean that the commodities may be either damaged by mold or in a condition favorable to molding by the time they reach marketing channels.

Modern farming know-how and equipment make it possible to keep mold levels to a minimum. However, certain changes in farming methods can complicate the mold problem unless the new technology is applied effectively. With mechanization, the trend is toward harvesting crops at a higher moisture content. Mechanical harvesting equipment is not selective, and the presence of a high percentage of foreign matter in the harvested crop may contribute to the drying problem by increasing the moisture content and interfering with proper aeration. Also, the seed may be damaged in mechanical picking if the machinery is operated too fast or is not properly adjusted. Some heavy-producing varieties of crops are late maturing and therefore less likely to be ready for harvest in good drying weather. On the other hand, mechanical drying has made the modern farmer more independent of the weather by enabling him to control drying conditions. Thus he is able to produce top-quality grain harvested at the peak of its nutritive value—even in damp weather.

No nationwide studies have been made to determine how much moldy grain and oilseed enters commercial channels. However, a significant amount of grain and oilseed shipped from principal marketing centers is of Sample Grade, which frequently contains molds. Although the percentage of total shipments receiving Sample Grade designation is small, the large volume of grain and oilseed shipped means that even these small percentages may represent millions of bushels. This potential for molds and perhaps for toxicity is added reason for intensified effort toward quality improvement.

Although recommended measures for preventing molds on the farm are generally emphasized by agricultural leaders and fairly well known to farmers, they are sometimes overlooked or slighted for various reasons such as work pressure or lack of suitable facilities. In addition, research is continually adding new refinements to the technology of mold prevention. Therefore, county agents have an important place in the educational drive to prevent mold in farm commodities. Despite limitations in our knowledge concerning molds, present know-how is sufficient to reduce mold damage sharply.

GENERAL PRINCIPLES AND PRACTICES FOR PREVENTING MOLD

Although recommended procedures for preventing mold damage vary with the crop, its stage of maturity, and environmental conditions, certain broad principles apply to most oilseed and grain crops.

High moisture is the single most important condition contributing to mold. Consequently, it is essential to dry the commodity to a safe moisture level as soon after harvest as practicable without damaging it, and to maintain the crop at a low moisture level during storage and handling.

Warm temperature also encourages molding. Molds grow most rapidly at temperatures of 60° to 100°F. in combination with high relative humidities.

Other conditions favorable to mold formation are damage to seed or kernels from insects or mishandling, and presence of foreign matter.

Here are some basic approaches to mold prevention:

Mold prevention is thought to begin with properly planting and growing the crop. Such practices as using sound, fungus-free, viable seed, fertilizing properly, and controlling insects and diseases not only increase vigor of the growing plants but, in the opinion of scientists, should also reduce the likelihood of mold establishment in the plant product at maturity. Prevention of lodging is another safeguard.

Harvesting promptly at maturity is another generally recommended practice. Moisture content is higher in immature crops and their susceptibility to mold damage greater. But permitting the crop to stand in the field after ripening can be an invitation to insect or mold invasion. In harvesting, equipment should be properly adjusted and operated at a moderate speed to avoid damaging the crop and picking up large amounts of leaves and dirt along with the harvest.

Since moisture control is crucial in mold prevention, testing for moisture content after harvest and prompt drying to the recommended level for safe storage are important. Adequate aeration is essential in all systems of drying to assure that the entire crop is dried to the recommended level. The safe moisture level varies with the crop, how long the commodity will be kept in storage, weather conditions in the area, and design of storage facilities. Recommended safe moisture levels refer to *all* the seeds or kernels in the lot dried or stored—*not the average* moisture content.

Oilseed and grain crops should be cleaned thoroughly to remove as much foreign matter and damaged seed as possible. And if part of the crop has lodged or otherwise been exposed to mold, it may pay to store it separately. By interfering with proper aeration, foreign matter, broken seeds or kernels, and grain dust not only obstruct even drying but make it more difficult to maintain grains and oilseeds at safe moisture levels.

After crops are dried to so-called safe levels, there is no assurance that they will remain at these levels in storage unless proper conditions are provided. The need for weathertight bins to prevent dried grains and oilseed from rewetting is obvious. Proper aeration is also essential. This problem is aggravated when large masses of grain are stored together, when there are severe changes in weather, or when the storage is of long duration. Without adequate aeration, significant differences in temperature between different locations in stored grain build up, causing the moisture to concentrate in damaging levels in the colder spots. Under some circumstances, mechanical ventilation is required to assure adequate aeration but in others suitable design and placement to take advantage of natural air movement will suffice.

Even if storage is temporary pending marketing, the storage area should be clean and the crop kept cool and dry during storage. Good insect control practices should also be used.

Crops stored on the farm should be checked regularly to make sure that excess moisture, insects, and mold are not developing in them.

Peanuts

Peanuts are more like green vegetables than most oil and cereal crops in the care they require in harvest, handling, and storage to prevent mold damage.

When dug, peanuts usually have an average moisture content between 35 and 55 percent with individual seed on the same plant ranging from below 30 to as much as 70 percent moisture. For safe storage this must be reduced to about 8 percent as soon as possible.

Combines, not being completely selective, pick up earth and foreign matter. This introduces molds and complicates the drying process.

Damaged peanuts are particularly susceptible to mold. Damage prevention begins with effective pod-insect and disease control during the growing period and continues through harvest with use of properly adjusted machinery operated at moderate speeds. Peanuts should be checked frequently during harvest to make sure they are not being damaged by operating the combines at excessive speeds.

Because moist peanuts are susceptible to mold, it is essential to dry them as promptly as practical. This calls for the proper combination of field and mechanical drying.

Field drying methods naturally vary with climatic conditions of the particular growing area. Research indicates that in the Virginia-Carolina area, curing in windrows for 4 to 8 days prepares peanuts for mechanical drying and under favorable weather conditions reduces the moisture content to around 25 percent. In the Southeast and in the Southwest, curing in windrows for 3 to 6 days under favorable conditions will usually lower moisture content to 10 percent or less. Under unfavorable conditions, the time peanuts are left in the windrow should be shortened if possible and more of the moisture removed with heated air to avoid the danger of molding.

Under properly controlled conditions, peanuts can be dried fast enough in a heated-air dryer to minimize molding without significant sacrifice of quality.

With a *batch-type, deep-layer dryer,* peanuts can usually be dried without excessive quality loss using air temperatures 10° to 15° F. above the outside temperatures but not above 95° F. An airflow between 10 and 20 cubic feet per minute for each cubic foot of peanuts is used in this relatively long drying process.

Current research shows that the Spanish and runner types of peanuts with lower moisture content can be dried faster with good results in *commercial-type, shallow-layer dryers* using air temperatures of 125° F. and possibly higher. Because exposure to heated air is so brief in this process, peanut temperatures can be held below the critical level. In shallow-layer dryers, the faster drying accomplished during the initial stages helps prevent molding.

Other Mold-Preventing Measures.—Soil should be removed from peanuts as soon after digging as possible. Delay in removing peanuts from truck or trailer can result in heating. Ideally, after peanuts are properly cured and dried, they should be stored in a cool, dry place until marketed. Exposing them to rewetting from rain or from moisture migration in hot, poorly ventilated bins can nullify the effect of initially drying the peanuts to a safe level.

Cottonseed

Good farm management practices and proper handling in processing and marketing channels are the best safeguard against molding in cottonseed.

In the few isolated areas where *Aspergillus flavus* has been found in growing cotton, it is usually associated with hot, humid conditions and excessive plant growth. The humidity may be due either to the weather or to excessive irrigation.

It has not been established whether the mold strains found in growing cotton are capable of producing toxins. In the past, concern over *Aspergillus flavus* in growing cotton centered on the fact that the organism yellows and downgrades the lint. Recently, however, studies by USDA in cooperation with the cottonseed industry have begun to determine whether these or other strains of toxin-producing molds are significant in the contamination of cotton and cottonseed products—a problem now thought to be small. This knowledge would enable farmers and processors to take extra precautions against mold if necessary.

To minimize the mold problem during the growing period, farmers should use just enough fertilizer and irrigation water for optimum growth. Overfertilization and overirrigation promote rank growth and boll rot on the lower portion of the plant. Bottom defoliation when these lower bolls are mature is known to prevent boll rot, which is caused by some molds.

To avoid exposure to rain or high humidity in the field, cotton should be harvested as soon after opening as economically feasible. To prevent mold developing after the cotton is harvested, farmers should try to avoid harvesting the cotton when it is damp. In many cotton-producing areas, the Weather Bureau supplies daily information on the time when the morning dew will be dried sufficiently for picking.

Mechanical cotton pickers should be operated carefully to prevent seed cracking, which might provide the opportunity for molds to invade the kernel.

Farmers and ginners should not leave the harvested cotton standing for long periods in trailers where it is exposed to wetting and heating. If the seed cotton moisture is high or if the trailer load contains large amounts of green leaves or other trash, even 24 hours is long enough for the cotton to deteriorate and mold to begin to grow.

In storage of cottonseed, reducing the moisture and temperature to safe levels is important for mold prevention. Cottonseed with about 10 percent moisture content has been stored without known significant damage. Maintaining clean storage facilities and keeping damaged seed separated from sound seed should help reduce the danger of contamination.

Soybeans

With soybeans as with other oilseeds and small grain, avoiding seed damage and reducing the moisture content to safe levels promptly after harvest is important to prevent mold.

Combines should be operated at a speed that threshes properly but doesn't crack the seed. As the moisture content of the soybeans in the field may change during the day, it may be necessary to adjust the combine periodically to reduce splits and other damage.

Soybeans should be kept clean, dry, and cool. This requires clean, tight bins as well as good practices in growing, harvesting, and drying the crop.

Ear Corn

Where natural ventilation is used for drying, harvesting of late-maturing corn should be delayed as long as possible to get maximum benefit from field drying. With a mechanical drying system, the corn should be dried promptly after harvesting.

Harvesting can be started several days earlier with a machine that husks clean than with a less efficient one. Husks and silks in harvested corn interfere with air movement through it. As a result, drying is slower and less even, and the chances of heating and molding are greater. For the same reason, shelled corn, chaff, dirt and other materials that fill space between ears should be removed before storage.

The risk of spoilage increases with the moisture content. Ear corn with 20 percent or more moisture is susceptible to mold damage in ventilated bins. For storage in unventilated cribs, ear corn should be dried to a kernel moisture of 13 percent or less before storage.

If corn stored over winter in ventilated cribs is to be kept in storage into warm weather, it should be shelled and dried to a kernel moisture of 13 percent or less at the approach of warm weather. In the Southern region, drying to 11 percent moisture is recommended.

Shelled Corn, Most Other Grains

Before storing wheat, grain sorghum, oats, or shelled corn, the dry grain should be cleaned if it contains more than a minimum of cracked or broken kernels, chaff, and dust. The chance of insect infestation and mold growth is increased by the presence of damaged kernels and foreign matter.

Safe moisture levels for storing grain vary with the region in which it is stored. A moisture content of 13 percent or less is recommended for the central Corn Belt. In warmer areas the moisture level should be 1 to 2 percent lower.

Agricultural researchers emphasize that recommended moisture levels apply to *all* the grain to be stored—not the average moisture level of the lot. When some portions of the grain are insufficiently dried or accumulate moisture due to inadequate ventilation or heating, mold is likely to grow in the wet grain and spread to the drier grain.

Grain can be dried to safe storage levels in any season or climate with heated air. However, in many climates unheated air is adequate to do the job. Drying should be started promptly after harvest and should proceed continuously at a rate fast enough to complete drying before mold can develop. In using heated air, temperatures should be kept low enough to avoid heat damage. For grain to be used for seed, 110° is generally the upper limit. For milling, temperatures between 145° and 160° may be safely used and for feeds, 190° to 200°.

Bins should be sound, weathertight, and adequately ventilated. Small leaks can cause serious damage to the grain.

Rice

Rice should be cleaned thoroughly before drying. If the grain coming from the combine contains a high percentage of weed seeds, leaves, stems, and other trash, the moisture content is usually higher than for the rice alone.

When desiccants are used on growing rice, they should be applied only after the moisture content of the rice has dropped to 28 percent and the crop should be harvested before the moisture drops to 17 percent.

When rice is harvested at moisture levels of 20 percent or more, drying should be started within 12 hours and continue until a moisture level of between 12 and 14 percent is reached.

Recommended practices for safe storing over long periods or under adverse weather conditions are similar to those for other grains.

UNKNOWNS BEING INVESTIGATED

Despite current interest in mycotoxins, limited research in the past has left many questions still unanswered. To get more precise information about the extent and seriousness of the problem and develop improved methods for meeting it, USDA, the Department of Health, Education, and Welfare, and a number of State agricultural experiment stations and universities and private research institutions have stepped up their research.

A number of important agricultural commodities are being surveyed for possible occurrence of mycotoxins. A quicker, cheaper method for detecting the presence of aflatoxin and other mold-caused toxins is being developed. While we understand in general what temperature, humidity, and other environmental conditions cause toxin-producing mold strains to develop, more precise information is being sought. That knowledge would make it possible to control molds and toxins at minimal cost. Improved techniques for growing, harvesting, drying, and storing crops to prevent the development of mold are also being investigated by Federal and State researchers.

USDA and State agricultural experiment stations, partly supported by the cotton and cottonseed industry, are trying to develop cottons with more impermeable seedcoats. It is thought that this would make it more difficult for molds to invade the seed. Another longterm undertaking is the development of strains of commercial-grade peanuts resistant to toxic molds. A practical method of destroying or extracting any mycotoxins that may develop in farm products so they will be safe for food and feed, is likewise being sought. Ways of salvaging peanuts or other commodities found unsafe for consumption by humans or animals because of mycotoxins are also being looked for.

LOOKING AHEAD

The potential for molds and possibly for toxicity in low-grade foods and feeds accents a long-standing concern for quality. Consequently, the prevention of molds in agricultural products will probably take on added importance in future years regardless of what we learn from current investigations of mycotoxins.

At this time there is no way of forecasting what these investigations will turn up. But should the extent and seriousness of mycotoxin injury to livestock be found greater than present evidence suggests, increased emphasis on mold prevention could result. Under such circumstances, major changes in methods of handling, drying, and storing crops could be adopted—and grading of crops could be modified to place higher emphasis and greater financial premium on crops which are marketed in a mold-free and mold-resistant state.

It seems likely that steady advances in basic knowledge and in techniques for growing, harvesting, and handling crops will make it easier to produce and market commodities that are free of mold damage.

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